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**DIRECTIONAL WIND COMPONENT
FREQUENCY ENVELOPES, SANTA
MONICA, CALIFORNIA (PACIFIC
MISSILE RANGE)**

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NASA

*George C. Marshall
Space Flight Center,
Huntsville, Alabama*

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20592 ABSTRACT A

Directional Wind Component Frequency Envelopes for Santa Monica, California, based on the "windiest monthly period" concept, are presented in this report for use in structural and control studies in the design of aerospace vehicles.

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TERRESTRIAL ENVIRONMENT GROUP
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SUMMARY

Directional Wind Component Frequency Envelopes for Santa Monica, California, based on the "windiest monthly period" concept, are presented in this report for use in structural and control studies in the design of aerospace vehicles.

I. INTRODUCTION

This report, similar to NASA TM X-53009 (Ref. 1), is an attempt to present data for use in developing idealized wind component profiles analogous to the synthetic wind speed profiles which are presently being used for aerospace vehicle design criteria by many organizations. Due to the predominance of strong northwesterly winds in the winter and lighter persistent southwesterly winds in the lower levels and easterly winds in the higher levels in summer in the troposphere over Santa Monica, California (Pacific Missile Range), some potential gain in structural and control system design requirements may be realized by using directionalized synthetic wind profiles instead of employing nondirectional wind speed synthetic profiles (Ref. 2). The extent of a design gain depends upon the flight azimuth restrictions imposed on the vehicle and the response characteristics of a given vehicle configuration.

II. DESCRIPTION OF BASIC DATA

The basic data used to prepare these graphs and tables consist of five years of rawinsonde wind data (1956-1960) which were serially completed (missing data inserted by interpolation, extrapolation, or use of data from nearby stations) by professional meteorologists of the

National Weather Records Center. Wind speed and direction are given for each kilometer of altitude from the surface to 27 kilometers. Therefore, the statistical values quoted are with reference to this basic set of wind profile measurements made four times daily for a period of five years. The data do not include the turbulence and high frequency component of the vertical wind profile, and therefore, represent the "steady state" part of the true wind profile characteristics.

III. PREPARATION OF GRAPHS AND TABLES

The wind speeds and directions were resolved to components with respect to a rotating orthogonal coordinate system which was rotated in increments of 15 degrees. By convention, at Marshall Space Flight Center the positive longitudinal and negative longitudinal wind components are considered as tail wind and head wind components, respectively. Similarly, the positive and negative lateral wind components are right-cross and left-cross wind components, respectively. Since the algebraic signs of the wind components with respect to the orthogonal planes are retained, unbounded frequency distributions are obtained. Cumulative percentage frequencies are computed. Then, the numerical values of the longitudinal and lateral wind components corresponding to the cumulative percentage frequencies of 30, 50, 90, 95, and 99 and the complements of these frequencies (i.e., 1, 5, 10, 50, 70%) are calculated. These operations produce values of the tail and right-cross wind components at stated cumulative percentage frequencies and the values of the head and left-cross wind components are obtained from the complements of the stated cumulative percentage frequencies. The values of the wind components (in m/sec) corresponding to the cumulative percentage frequencies are called percentiles. The relation between percentiles and probability follows immediately: given that the 90th percentile of the wind component is say, 60 m/sec, means that there is a probability of 0.90 that this value of the wind component will not be exceeded and there is probability of 0.10 that it will be exceeded for the set of data from which the percentile was computed. Stated in another way: there is a 90% chance that the given wind component will not be exceeded or there is a 10% chance that it will be exceeded. If one considers the 10th and 90th percentile for the wind components, it is clear that 80% of the wind components occur within the 10-90 percentile range.

The percentiles were computed for the wind components at one kilometer altitude intervals from the surface to 27 kilometers for each monthly period. Envelopes for the monthly percentiles were constructed for all altitude levels. From these monthly percentile envelopes, envelopes were constructed which enclosed all monthly percentile envelopes and idealized by linear segments for the 5 to 6, 10 to 13, and 18 to 20-kilometers altitude intervals. These idealized wind component envelopes for the several percentiles are presented for the discrete altitudes 5 to 6 kilometers, 10 to 13 kilometers, and 18 to 20 kilometers in Figures 1, 2, and 3, and Tables I, II, and III. The 99 percentile envelope for each of the three altitude intervals is illustrated in Figure 4. Similarly, the 95 percentile envelope is shown in Figure 5.

IV. WINDIEST MONTHLY REFERENCE PERIOD CONCEPT

As used in this document, the wind data for the various percentiles refer to the "windiest monthly period." This means that the wind speed values were computed for the given cumulative percentage frequencies or probability levels for each of the twelve monthly periods represented by the five years of data, i.e., five Januaries, five Februaries, etc. The maximum wind speed value of all the twelve monthly periods was selected for each percentile, as noted in Section III. This produced a wind speed value for each 15 degrees of azimuth, for a given percentile, not exceeded by the observations from the windiest month. Obviously, the wind speed values for a given percentile envelope may come from different months, depending on the strength and persistence of the wind speeds for the various azimuths.

The philosophy is to produce a set of statistics such that the maximum wind component value for a given percentile may be readily determined for a given azimuth, based on a windiest monthly reference period concept. It is therefore evident that, in general, only one monthly period will control the selected component wind speed value for a given azimuth altitude and percentile. For the other eleven monthly periods, a smaller value of the wind component will exist. However, where there is concern for insuring that the largest wind component value for a given percentile during a monthly period is determined, this type of presentation insures selection with a minimum effort.

V. USE OF DATA

Interpretation of the data from this report is as follows: wind component envelopes for cumulative percentage frequencies of 30%, 50%, 75%, 90%, 95%, and 99% are provided for three altitude regions: 5 to 6 km (Figure 1 and Table I), 10 to 13 km (Figure 2 and Table II)

and 18 to 20 km (Figure 3 and Table III). The graphs and tables may be used to answer the following type question: for a given flight azimuth--say to 285 degrees from north at an altitude between 10 and 13 km--what is the head, tail, right-cross or left-cross wind component which will not be exceeded 95 percent of the time for the windiest monthly period? For this case there is a 95 percent chance that a head wind will not exceed 63 m/sec; for the right-cross it is 34 m/sec; for the tail wind it is 11 m/sec; and for the left-cross wind it is 38 m/sec (see Figure 2). Similar questions can be answered for any given flight azimuth with respect to the wind component magnitudes in various altitude regions. Similarly, with respect to this graph, information can be obtained for those vehicles which are critical to quartering winds--that is, for a flight azimuth of 285 degrees, at 10 to 14-km altitude region, it might be determined that a wind component acting from 60 degrees and 150 degrees might be the most critical. For this case, there is a 95 percent chance that the right quartering wind component will not exceed 24 m/sec and the left quartering wind component will not exceed 18 m/sec.

If information is required for altitudes between those given, linear interpolation may be used as follows to obtain a first approximation:

- a. To find the head wind value at 8 km associated with the 95 percent value for a 285 degree flight azimuth, the 95 percent value for 5 to 6 km is 40 m/sec (see Figure 1) and for 10 to 13 km (10 km) is 63 m/sec (see Figure 2); therefore, by interpolation

$$\left(\frac{8 - 6}{10 - 6}\right)(63 - 40) + 40 = 11.5 + 40 = 51.5 \text{ m/sec.}$$

Note that the bottom of the 10 to 13 km altitude wind zone is used, since this is the maximum wind zone; and all velocities are assumed the same in this zone, for the purpose of this calculation, at given percentile levels.

- b. To find a wind value between the 10 to 13 km and 18 to 20-km region, interpolation will be made between 13 km and 18 km.
- c. Interpolation should be performed only within one plane, that is, with respect to altitude and wind component. Interpolations between altitude and wind components along different azimuths are not valid.

It should be pointed out that the graphical scales of wind speed vary between the graphs. This was necessary to present the data in the most useful form. Figures 4 and 5 show the 99% and 95% percentile wind speeds on the same scale so that the relative wind speeds for the various altitude levels can be compared.

VI. CONCLUDING REMARKS

These data should be employed in vehicle studies with caution. The responsible organizational wind criteria groups should be contacted before any final decisions are made on design problems using this information to insure proper interpretations of these data. Within Marshall Space Flight Center this group is the Aero-Astrodynamic Laboratory, Aero-Astrophysics Office.

REFERENCES

1. Smith, O. E. and Glenn E. Daniels, "Directional Wind Component Frequency Envelopes, Cape Kennedy, Florida, Atlantic Missile Range," NASA TN X 53009, February 21, 1964.
2. Daniels, Glenn E., "Terrestrial Environment (Climatic) Criteria Guidelines For Use In Space Vehicle Development, 1964 Revision," NASA TM X-53023, March 13, 1964.

TABLE I

ENVELOPES OF IDEALIZED MONTHLY WIND COMPONENT (HEAD, TAIL, RIGHT-CROSS
AND LEFT-CROSS) FREQUENCY DISTRIBUTIONS, FOR 5 TO 6-KILOMETERS ALTITUDE,
AS A FUNCTION OF FLIGHT AZIMUTHS, SANTA MONICA, CALIFORNIA
BASED ON WINDIEST MONTHLY REFERENCE PERIOD CONCEPT

Azimuth*	Percentiles					
	30	50	75	90	95	99
	(meters/second)					
0	0	4	12	21	28	38
15	0	3	9	18	24	34
30	0	2	8	16	22	31
45	0	1	6	13	18	26
60	0	1	5	12	17	24
75	0	0	3	10	14	20
90	0	0	2	8	12	17
105	0	0	2	7	11	16
120	0	0	3	7	10	16
135	0	1	3	8	10	17
150	1	2	5	9	12	21
165	1	3	7	11	15	25
180	2	4	9	15	20	30
195	3	6	12	19	25	34
210	3	7	13	22	28	39
225	4	8	17	26	31	43
240	6	12	19	27	35	45
255	8	14	20	28	35	48
270	9	15	22	30	35	47
285	10	15	22	32	40	51
300	9	12	20	28	34	42
315	6	11	20	29	35	43
330	5	8	15	25	32	40
345	3	6	14	23	29	38
360	0	4	12	21	28	38

*Direction from which wind component is blowing.
Referenced clockwise from true north.

TABLE II

ENVELOPES OF IDEALIZED MONTHLY WIND COMPONENT (HEAD, TAIL, RIGHT-CROSS
AND LEFT-CROSS) FREQUENCY DISTRIBUTIONS, FOR 10 TO 13-KILOMETERS ALTITUDE,
AS A FUNCTION OF FLIGHT AZIMUTHS, SANTA MONICA, CALIFORNIA
BASED ON WINDIEST MONTHLY REFERENCE PERIOD CONCEPT

Azimuth*	Percentiles					
	30	50	75	90	95	99
	(meters/second)					
0	0	6	18	32	40	51
15	0	3	13	26	34	47
30	0	0	10	24	32	45
45	0	0	7	20	29	40
60	0	0	5	16	24	33
75	0	0	3	11	18	28
90	0	0	1	5	9	17
105	0	0	1	7	11	19
120	0	0	2	8	12	20
135	0	1	5	10	14	24
150	0	2	8	14	18	28
165	2	6	12	18	22	34
180	4	9	16	24	30	43
195	7	12	22	32	38	50
210	9	14	26	38	47	58
225	12	19	31	44	53	69
240	16	24	37	48	57	73
255	22	29	40	51	59	76
270	23	29	41	54	61	74
285	22	28	40	55	63	78
300	20	27	39	50	59	73
315	16	21	34	50	60	71
330	10	17	31	46	55	65
345	3	10	25	40	48	60
360	0	6	18	32	40	51

*Direction from which wind component is blowing.
Referenced clockwise from true north.

TABLE III

ENVELOPES OF IDEALIZED MONTHLY WIND COMPONENT (HEAD, TAIL, RIGHT-CROSS,
AND LEFT-CROSS) FREQUENCY DISTRIBUTIONS, FOR 18 TO 20-KILOMETERS ALTITUDE,
AS A FUNCTION OF FLIGHT AZIMUTHS, SANTA MONICA, CALIFORNIA
BASED ON WINDIEST MONTHLY REFERENCE PERIOD CONCEPT

Azimuth*	Percentiles					
	30	50	75	90	95	99
	(meters/second)					
0	1	3	6	10	13	17
15	0	2	5	8	11	14
30	1	2	4	8	11	16
45	3	4	6	9	11	15
60	4	6	8	10	12	14
75	4	6	8	11	12	14
90	5	6	8	11	13	15
105	5	7	10	12	13	15
120	3	5	7	9	10	12
135	2	4	6	8	9	12
150	1	3	5	6	7	10
165	1	2	4	5	6	10
180	0	0	3	6	8	13
195	1	2	5	10	12	17
210	2	4	7	11	15	23
225	2	4	9	15	19	26
240	5	7	10	16	19	26
255	5	8	12	17	20	28
270	5	8	12	18	21	29
285	5	8	13	19	23	31
300	7	10	14	19	22	27
315	6	8	11	17	20	25
330	4	7	10	14	17	22
345	2	4	8	12	15	20
360	1	3	6	10	13	17

*Direction from which wind component is blowing.
Referenced clockwise from true north.

Based on Five Years Rawinsonde
Serially Complete Data Record
R-AERO-YT, March 5, 1964

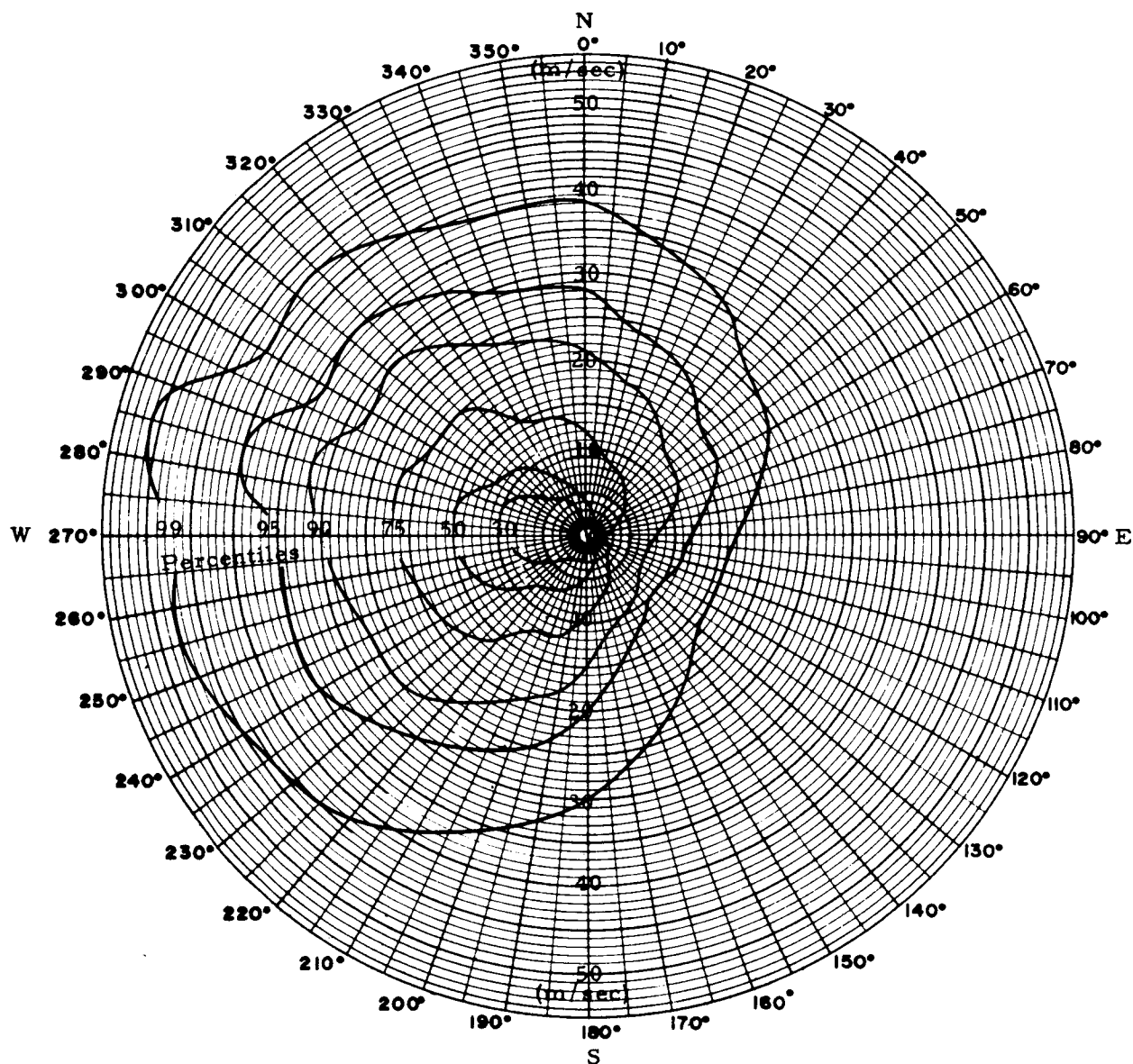


FIGURE 1. ENVELOPES OF IDEALIZED MONTHLY WIND COMPONENT (HEAD, TAIL, RIGHT CROSS, AND LEFT CROSS) FREQUENCY DISTRIBUTIONS, FOR 5 TO 6-km ALTITUDE, AS A FUNCTION OF FLIGHT AZIMUTHS, SANTA MONICA, CALIFORNIA. BASED ON WINDIEST MONTHLY REFERENCE PERIOD CONCEPT.

Based on Five Years Rawinsonde
Serially Complete Data Record
R-AERO-YT, March 5, 1964

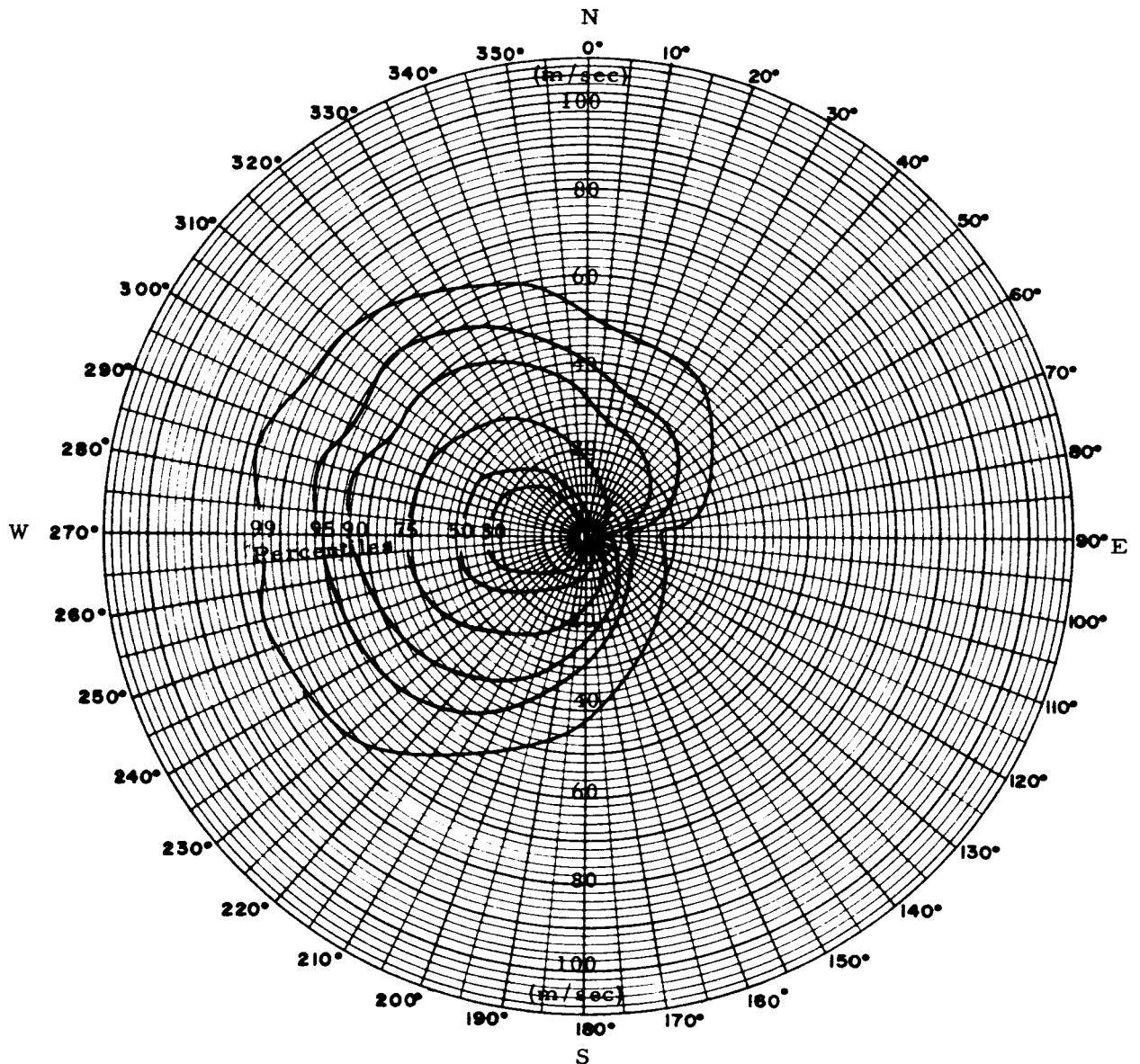


FIGURE 2. ENVELOPES OF IDEALIZED MONTHLY WIND COMPONENT (HEAD, TAIL, RIGHT CROSS, AND LEFT CROSS) FREQUENCY DISTRIBUTIONS, FOR 10 TO 13-km ALTITUDE, AS A FUNCTION OF FLIGHT AZIMUTHS, SANTA MONICA, CALIFORNIA. BASED ON WINDIEST MONTHLY REFERENCE PERIOD CONCEPT.

Based on Five Years Rawinsonde
Serially Complete Data Record
R-AERO-YT, March 5, 1964

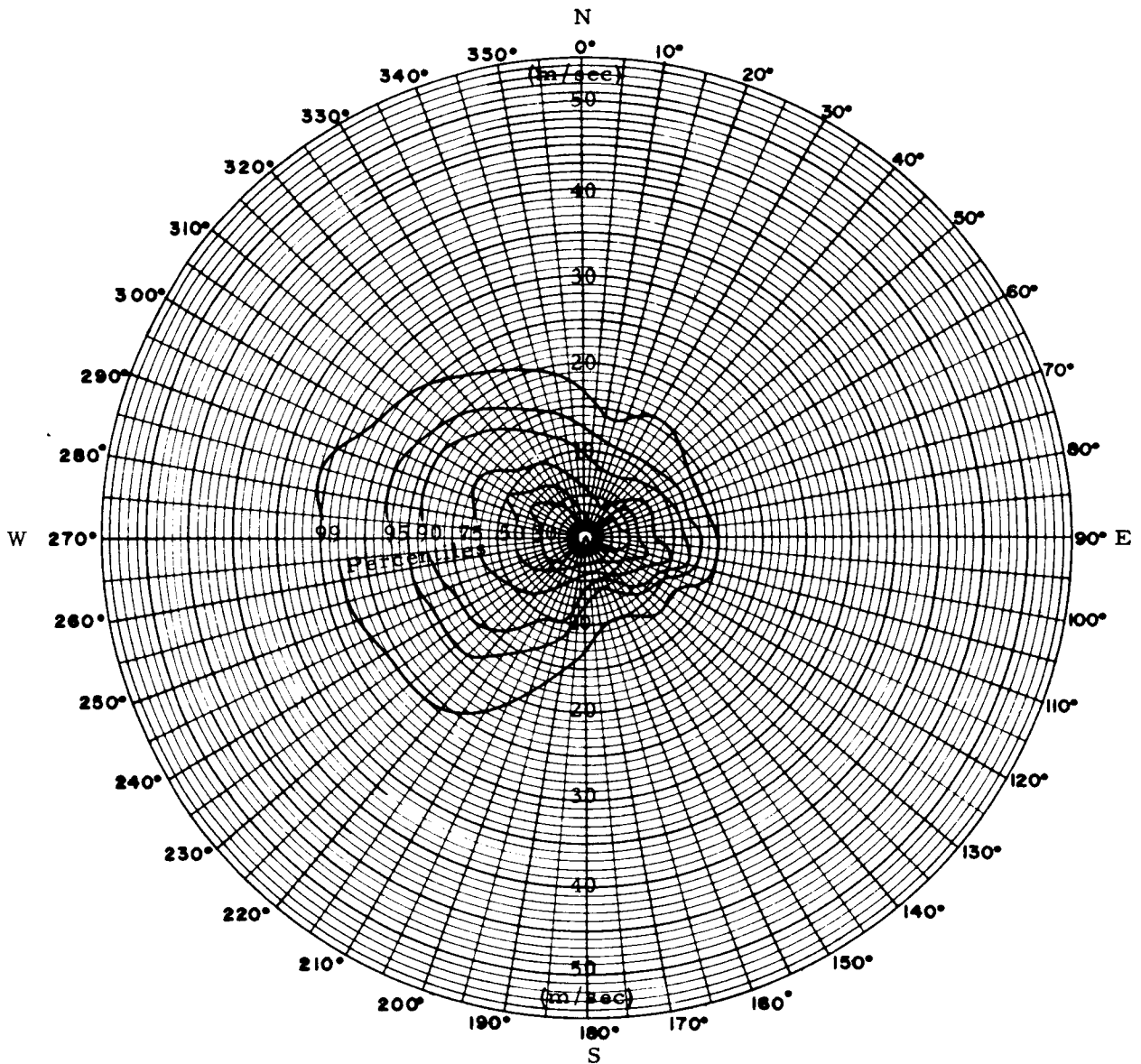


FIGURE 3. ENVELOPES OF IDEALIZED MONTHLY WIND COMPONENT (HEAD, TAIL, RIGHT CROSS, AND LEFT CROSS) FREQUENCY DISTRIBUTIONS FOR 18 TO 20-km ALTITUDE, AS A FUNCTION OF FLIGHT AZIMUTHS, SANTA MONICA, CALIFORNIA. BASED ON WINDIEST MONTHLY REFERENCE POINT CONCEPT.

Based on Five Years Rawinsonde
Serially Complete Data Record
R-AERO-YT, March 5, 1964

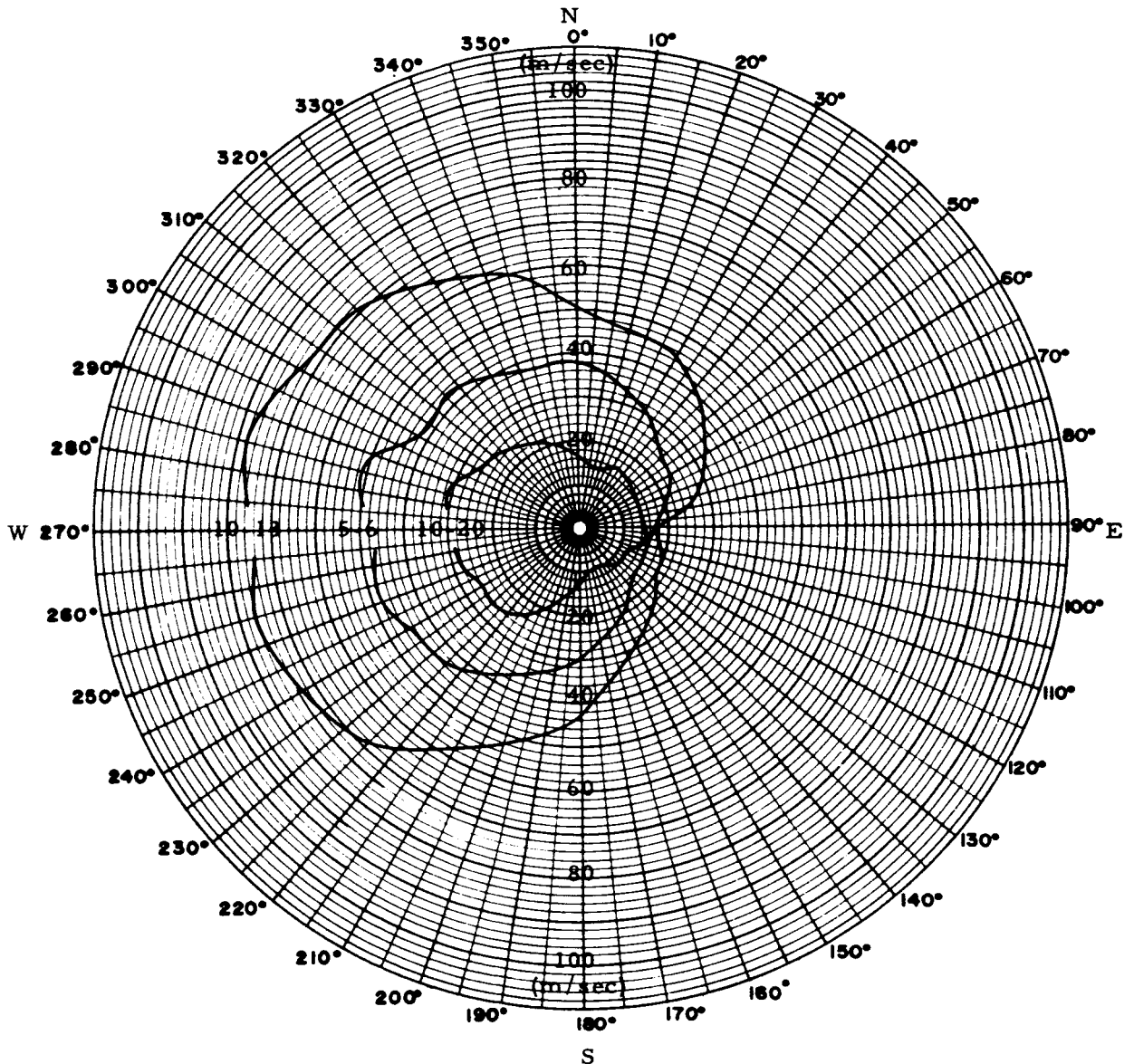


FIGURE 4. NINETY-NINE PERCENTILE ENVELOPES OF IDEALIZED MONTHLY WIND COMPONENTS, AS A FUNCTION OF FLIGHT AZIMUTHS, SANTA MONICA, CALIFORNIA, BASED ON WINDIEST MONTHLY REFERENCE PERIOD.

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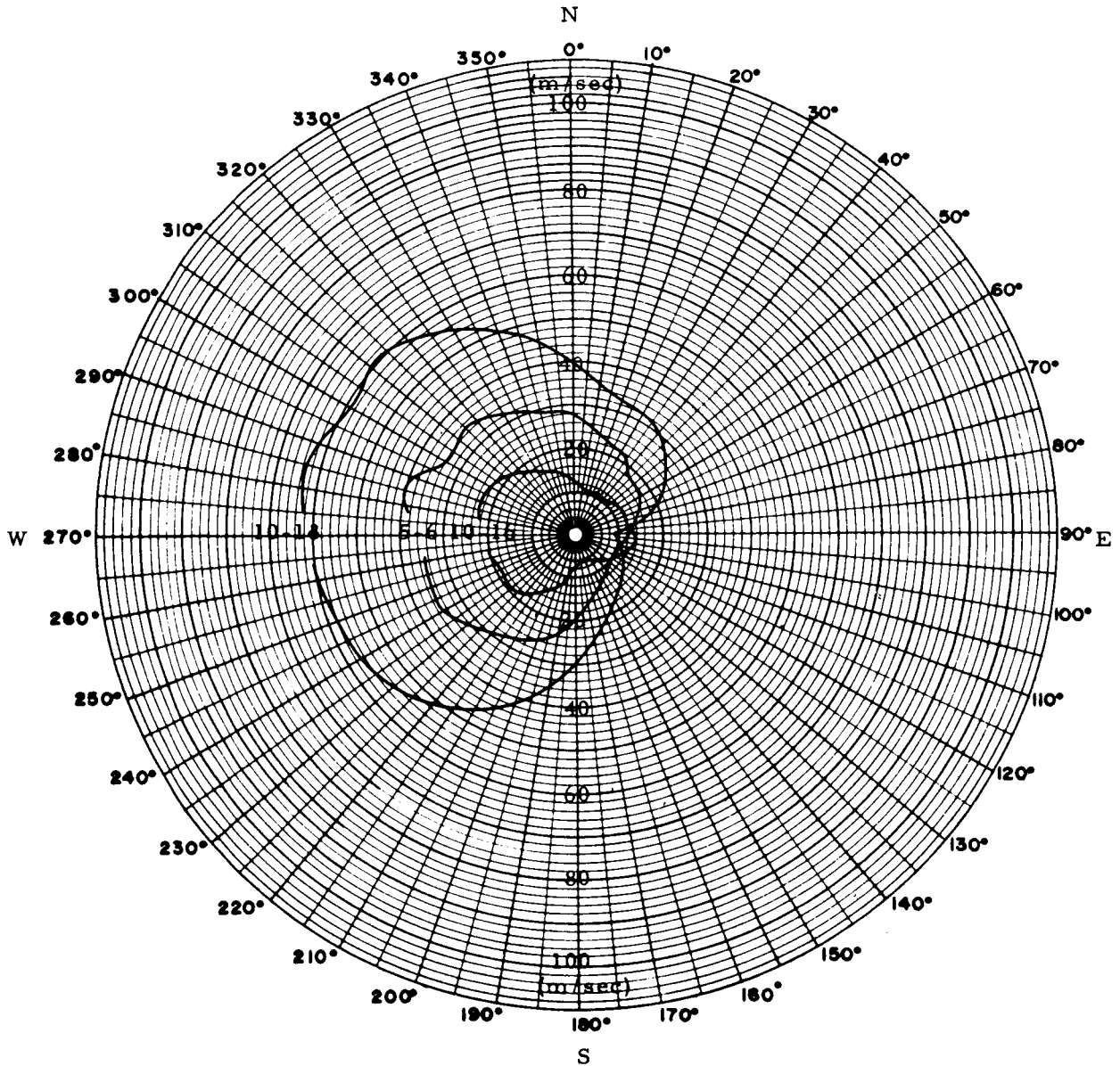


FIGURE 5. NINETY-FIVE PERCENTILE ENVELOPES OF IDEALIZED MONTHLY WIND COMPONENTS, AS A FUNCTION OF FLIGHT AZIMUTHS, SANTA MONICA, CALIFORNIA. BASED ON WINDIEST MONTHLY REFERENCE PERIOD.

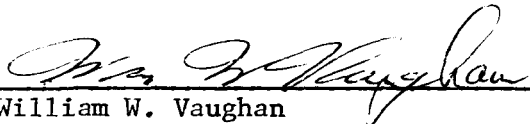
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